BioUpdate Foundation

Gas Phase Chemistry and Enzymatic Catalysis

Recently, I was asked to review a book. A book in which the author expressed great surprise that chemistry seemed to take place in space. He also seemed surprised that galactic chemistry was remarkably similar to terrestrial chemistry. In fact it is not, but certainly the rules of chemistry do not change in outer space. But other things do!

This thought took me back to my younger days and some ideas that the late Dudley Williams had, back in the late 1970s, about the basis of enzyme catalysis. I don't think Dudley ever published these ideas, but subsequently I have read a similar theory in print, but even that was 30 years ago.

I was a young scientist fascinated by the shape and complexity of proteins, and the relationship between the molecular structure and function of enzymes. The crystallographers were producing beautiful three dimensional models with appropriately charged species located in just the right place. This would explain why the reactions took place, but did it explain why the reaction rate was enhanced?

I think everything in science fascinated Dudley Williams and he had a very diverse research group. His ideas on enzyme catalysis did not come from a study of biochemistry but from what you might call a study of galactic chemistry. Along with a very industrious PhD student, Richard Bowen, Dudley was studying gas phase chemistry. Not industrial scale high pressure chemistry, but chemistry in a vacuum, or, to be more precise, chemistry in a mass spectrometer. The pressure inside a mass spectrometer is extremely low, a million times less than atmospheric pressure. What Dudley realised was that the conventional chemistry he taught was essentially chemistry in solution; what he saw in the mass spectrometer was chemistry in the absence of solvent. And the chemistry he saw was different.

My recollection is that activation energies were much less, which would explain increased reaction rates, but there were also some surprises which challenge our understanding of enzyme chemistry, because enzyme chemistry is essentially chemistry in the absence of solvent. One of the things I remember is that, in the gas phase, the proton affinity of benzene was greater than that of methanol, it is easier to protonate benzene than methanol. So galactic chemistry may well differ from terrestrial, solvent based, chemistry. More intriguingly, put this in the context of enzyme chemistry and the conclusion would be that it is easier to protonate phenylalanine than it is to protonate serine. This suggests that we should rethink our understanding of enzyme reaction mechanisms.

Dudley's hypothesis was quite simple. There is no bulk solvent in the active site of an enzyme, and the basis of enzyme catalysis, the real function of an enzyme, is simply to remove solvent.

Tony Auffret
February 2014